

Fast Migration of Plasma-Induced Defects in *p*-InP

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Plasma-assisted process has become the most important technique for the transfer of narrow lines in the development of semiconductor microstructures. Nevertheless, the subsurface layer of the processed wafers is usually degraded down to some 100 nm's, which is extremely deep compared with the projection range of ions in a gaseous plasma. The electrical activity of the shallow dopants, particularly acceptors in InP, is passivated by fast diffusing species during the plasma processing. On the other hand, hydrogen, one of the most common impurities and well-known deactivator of dopants, is easily introduced into semiconductors in virtually every step during the processing of semiconductor devices.

The motivation of this study is to elucidate electrical properties, physical origins, and introduction-migration mechanism of plasma induced defects in InP and to distinguish between intrinsic defects and hydrogen-related defects. In this paper, we report on an investigation into the time variation of the *C-V* profiles for *p*-InP:Zn exposed to Ar-plasma as well as atomic hydrogen.

The important results are as follows:

- (1) After Ar-plasma exposure, the passivation of Zn acceptors proceeded for a few days even at room temperature (Fig. 1). We tentatively label the concerning defect as defect "X".
- (2) If the sample was quenched immediately after the Ar-plasma exposure and preserved at 77 K, in-diffusion of the deactivator was reduced dramatically (Fig. 1(b)). The diffusion profile is quite similar to that of atomic hydrogen H.
- (3) The reverse bias annealing (RBA) was carried out for both defect X and atomic hydrogen in order to determine the parameters for diffusion and dissociation of the deactivator-Zn pairs. The resultant *C-V* profiles were analyzed by parameter fitting (Fig. 2). The model of dissociation and migration of the deactivator is formulated as eqs. (a) and (b).
- (4) The temperature dependence of the diffusion coefficient was measured for defect X and atomic hydrogen (Fig. 3). The result suggests that the diffusivity of defect X is lower than that of atomic hydrogen at low temperatures. Therefore, it can be speculated that during the low-temperature preservation (result (2)) the defect X's agglomerate and become immobile in the very vicinity of the surface.

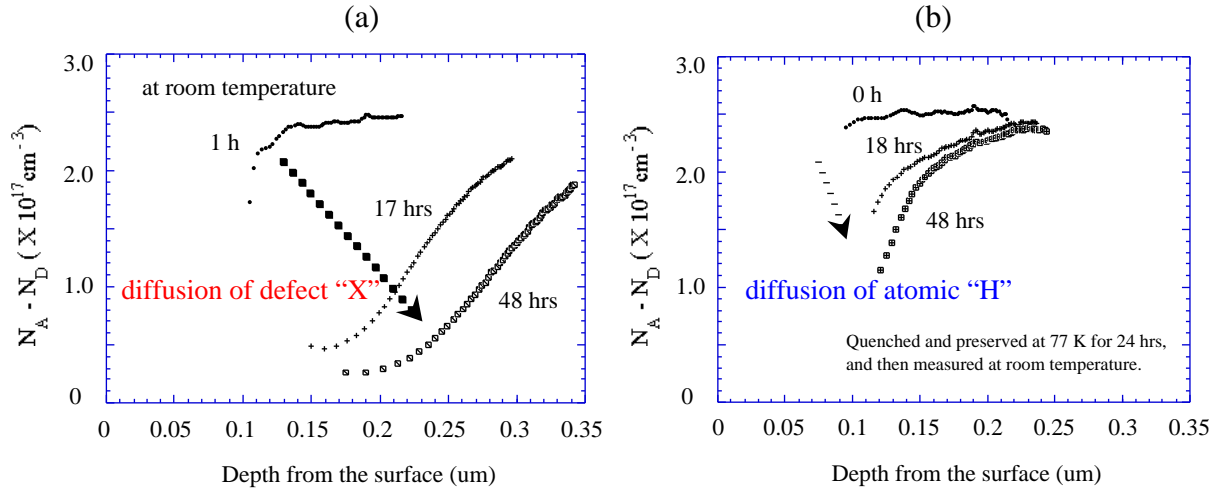


Fig. 1 The progress of the acceptor passivation at room temperature for *p*-InP:Zn exposed to Ar plasma. The sample was preserved at room temperature (a) all the time since exposure, and (b) after quenching and the followed preservation at 77 K for 24 hrs.

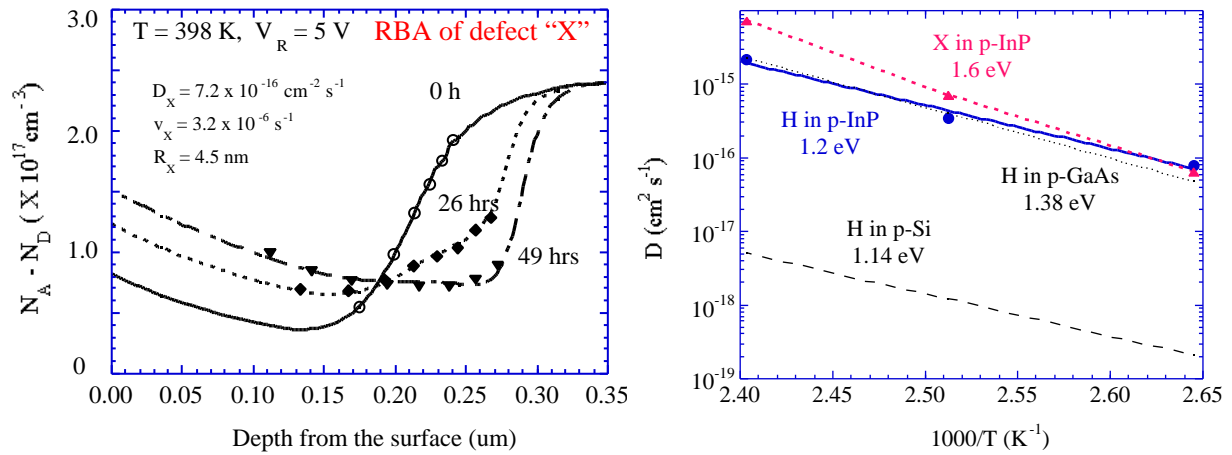


Fig.2 The variation of C-V profiles of the Ar-irradiated sample upon the reverse-bias annealing (RBA) at 398 K. the fitting curves are calculated by using the continuity equation (1) and rate equation (2) below.

$$\frac{\partial [X]}{\partial t} = D_X \frac{\partial^2 [X]}{\partial x^2} - q\mu_X \frac{\partial (E[X])}{\partial x} - \frac{\partial [Zn \ X]}{\partial t}, \quad (a)$$

$$\frac{\partial [Zn \ X]}{\partial t} = 4\pi R_B D_X [X] (N_{A0} - [Zn \ X]) - v_B [Zn \ X], \quad (b)$$

Fig.3 The Arrhenius plot of the diffusion coefficients of defect "X" and atomic hydrogen in *p*-InP.